BEST AVAILABLE COPY

Teledermatology in a Capitated Delivery System Using Distributed Information Architecture: Design and Development

JOSEPH C. KVEDAR, M.D.,^{1,2} ERIC R. MENN, B.A.,² SYAM BARADAGUNTA, B.A.,² OLGA SMULDERS-MEYER, M.D.,¹ and ERNESTO GONZALEZ, M.D.¹

ABSTRACT

Objective: This report describes the design, development, and technical evaluation of a teledermatology system utilizing digital images and electronic forms captured through, stored on, and viewed through a common web server in an urban capitated delivery system.

Materials and Methods: The authors designed a system whereby a primary care physician was able to seek a dermatologic consultation electronically, provide the specialist with digital images acquired according to a standardized protocol, and review the specialist response within 2 business days of the request. The settings were two primary care practices in eastern Massachusetts that were affiliated with a large integrated delivery system. Technical evaluation of the effectiveness of the system involved 18 patients. Main outcome measures included physician and patient satisfaction and comfort and efficiency of care delivery.

Results: In 15 cases, the consultant dermatologist was comfortable in providing definitive diagnosis and treatment recommendations. In 3 cases, additional information (laboratory studies or more history) was requested. There-were no-instances-where-the-dermatologist-felt-that a face-to-face-visit-was necessary.

Conclusions: This novel approach shows promise for the delivery of specialist expertise via the internet. Cost-effectiveness studies may be necessary for more widespread implementation.

INTRODUCTION

THIS ARTICLE DESCRIBES THE DESIGN, development, and initial technical evaluation of a teledermatology system create within an urban integrated delivery system. Partners Health-Care System, Inc., is composed of three tertiary care hospitals and several community hospitals, clinics, and physician practices. Presented here is a preliminary evaluation of the effectiveness of the system.

Up to 87% of primary care physicians (PCPs)

in practice today have had between 1 week and 1 month of formal dermatology training. The need for efficient management of skin diseases is underscored by the finding that, when viewing a slide set of 20 common dermatoses, PCPs make the correct diagnosis about 50% of the time compared with 90% to 95% for dermatologists. Dermatologists viewing a set of still digital images and dermatologists viewing patients' skin agree on a diagnosis ~80% of the time. Face-to-face clinicians are also in agreement ~80% to 90% of the time when examin-

¹Department of Dermatology, Harvard Medical School, Massachusetts General Hospital, Boston, Massachusetts.
²Partners HealthCare System, Inc., Boston, Massachusetts.

ing a group of patients with varying cutaneous diagnoses. Patients are particularly concerned about the appearance of their skin, and skin disease affects wellbeing in profound ways. Third-party payers are increasingly concerned with patient satisfaction and with quality-of-care measures, as well as cost-effectiveness and efficiency. 10-14 All these trends have resulted in a close examination of methods that enable primary providers to deliver higher-quality care without the additional cost of referrals to specialists. 15-17

It may be argued that physicians are familiar and comfortable with the care delivery mode characterized as store-and-forward technology, whether or not they use the term. Indeed, voice mail, fax, courier services, and e-mail all represent store-and-forward modalities. The Internet has not been studied as extensively as a communications tools for the delivery of care as other means of care delivery because it is new and became widely available only recently.

It may be argued that building blocks are required for an effective teledermatology system. It should be convenient for a referring practitioner to enter data and append images; the data collected should be standardized to maximize the historical details that would normally be obtained in an in-person interview; the data must emphasize nonvisual aspects of the physical exam to which the consultant dermatologist will not have access; there should be a standard method for image acquisition, and the method should interfere only minimally with office workflow and be of minimal inconvenience to patients and clinicians. Moreover, there should be a centralized database for storage of medical records and images providing access for both the specialists and the referring practitioner; the specialist must have convenient, multipoint access to the same information as the referring practitioner; and he or she must be able to provide prompt feedback in order to augment patient care. The reasons for this are convenience, practicality, and especially risk management. 18-22

Software and communications platforms for this process are still being designed and defined.^{23,24} Some have used point-to-point connections and software that has the functionality of electronic mail with attachments. Others

have created specific software solutions for telemedicine generally and teledermatology specifically. These software solutions often combine certain features of the electronic medical record with the capability of uploading images and image viewing. Current review of available products leads to the conclusion that no standard solution is in widespread use at this time.^{25–28}

This article describes a systematic approach for combining all of the above features to achieve ease of use for both PCPs and specialists without regard to time or geographic constraints. Further, the demonstration utilized off-the-shelf personal computers and components, eliminating the need for video cards or other computer modification.

Our-system uses the Internet as a communications vehicle and a World Wide Web browser as the presentation software (Fig. 1). The primary care site and the specialist's viewing station use the Web browser for their interactions. Images captured at the primary care site are downloaded to a server via the browser. In addition, we developed a standardized history and methods for identification of image area, as well as a protocol for image acquisition. A centralized Web server stores images and histories. The specialist can view history and images easily from any computer with an Internet connection. The secure system requires a user name and a password for access, and it uses secure socket layer encryption for each transaction. It is further secured by segmentation of access, limiting the specific information that can be downloaded by potential users based on their identification as referring physician, specialist, or imaging technician.

All primary care sites (affiliates of Partners HealthCare System, Inc.) had expressed an urgent need for expanded dermatologic coverage and became committed participants in this new health care delivery model. The development of this Web-based teledermatology system was undertaken to address these unmet needs. The software was developed in collaboration with Global Telemedix, Westford, MA using Lotus NotesTM on a DominoTM server. The software platform is being adapted to run on any World Wide Web server.

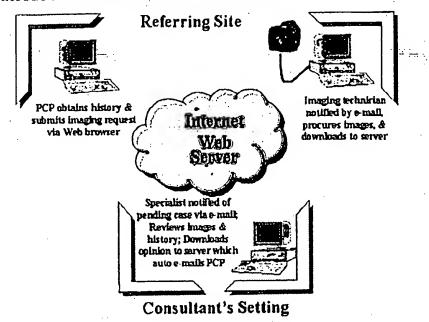


FIG. 1. Teledermatology electronic work flow.

PATIENTS AND METHODS

Study Subjects

After the system was installed at-two-sites, patient volunteers presenting with skin-related complaints at the Women's Health Associates at Massachusetts General Hospital and the Cape Ann Medical Center in Gloucester, Massachusetts, were invited to participate in a technical evaluation of the system. After giving informed consent, patients were randomized into two groups: One_group_underwent_digital imaging of skin conditions, the other received routine care as determined by the PCP. Initially, patients who chose to participate in the study had a skin condition diagnosed by the PCP. All skin conditions were eligible for inclusion in the preliminary evaluation except for acne, warts, and skin tags. Also, if patients experienced fever and/or chills as a result of the skin condition, they were not invited to take part in the study.

Service Process

History acquisition and consultation request. Following informed consent, if the patient were to undergo imaging, the PCP made note of the

area to be imaged either on a paper form or directly on a Web-based form developed for that purpose (Fig. 2). A PCP recorded a dermatology-specific patient history to accompany the request for imaging (Fig. 3). The consultation request also included the PCP's most likely diagnosis and a treatment plan. Previously trained imaging technicians employed by Partners Telemedicine and assigned to the participating sites obtained the requested images for uploading to the server for later review by the specialist.

Image acquisition. Image capture was achieved using Nikon_E2N_digital_cameras\ equipped with Nikon 105MM F2.8 lenses and Canfield Clinical Systems CCS Twin Flashes. The Nikon E2N was chosen because of its ability to render digital images providing the same aspect ratios as 35-mm film. A critical component of the imaging protocol was adherence to specific aspect ratios appropriate for imaging of lesions. Images were uploaded to a Web server and displayed on a standard PC monitor utilizing at least 800 × 600 pixel resolution and 32-bit color (Hewlett Packard HP Vectra 5 personal computer with a 133 Mz Pentium processor and 64 Mb of RAM. A Matrox Millenium graphics card

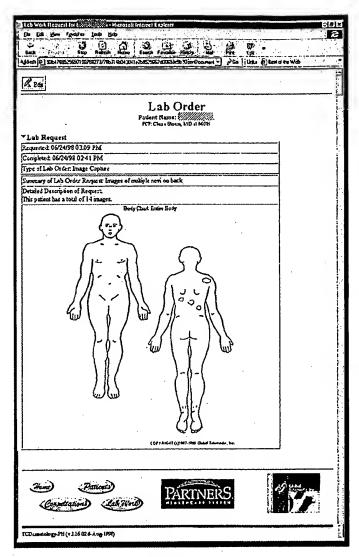


FIG. 2. Lab order.

was installed. The imaging monitor was a Mitsubishi Diamond Scan 20-inch monitor).

Images were acquired according to a standardized protocol developed by the Department of Dermatology (Fig. 4; complete protocol available from the corresponding author upon request). This protocol delineated explicit instructions for photography of the scalp, face, oral cavity, neck, trunk, extremities, anogenital areas, hands, and feet, including aspect ratios and angles of photography. In developing the imaging protocol, the aim was to produce a set of guide-

lines that required minimal interpretation on the part of the imaging technicians, none of whom were professional photographers.

Imaging technicians obtained a reproducible series of images for each case based on the anatomic location of the skin condition. Images were taken at a central location (imaging area) or in the examining room. The technician confirmed image clarity and reproduction ratio prior to releasing the patient. Because this was a preliminary technical evaluation, other important photographic elements such as color

| Reason for Visit via Type: Derreatabagic Problem There Complaint: Make Congenital New on back History of Present Illness the patient appear it! No then 6d this episode start? Mis then 6d this episode start? Mis there 6d it start? back fow long have you had this the distribution? Scattered That is the clien? waried light-dark brown with it the color? waried light-dark brown with it is consistency? four does a first to poo? The is the consistency? four does a first to poo? Other: Previous lix statuent. Does Lermatological history poose CP's most likely treatment derreatabologis? Would you have normally sent is princed to a dermatologis? Medical History are History gestric taker Ended to go to bee | Project Name of 1990 Project December Project D | | D D |
|--|--|--|--|
| the Date of Confession ID: 9806 34145744CH at The Co. 255 34 PM | Tais Dame 06/24/99 Fast Three 02 55 34 PM Lectical Code **Reason for Visit Viol Type: Dermantologic Problem Chair Complaine: Mult Congenital New on back **History of Present Illness Does patient appear it? No When 6d the reprode dart? Ma How long have you had this problem? When 6d it start? Dark How long have you had this problem? What is the darth bank of the color? Varied light dark brown What is the color? Varied light dark brown No What is the color? Varied light dark brown No Previous its starest. Done Dermantological history Done PCP's most lichy weathers plan Would you have cormally send this patient to a dermatologic real Madou. **Medical History Past History gastric uker Medical Cachole (OCP Medical Mistory. Sent History gastric uker Medical Mistory. Sent History gastric uker Medical Cachole (OCP Medical Mistory. Sent History gastric uker Medical History Sent History gastric uker CCP Medical History. Sent History gastric uker Medical History. Sent History gastric uker Medical History. Sent History gastric uker Medical History. Sent History. Sent History gastric uker Medical History. Sent History gastric uker Medical History. Sent History. | Out and N | Dermatologic Problem |
| Reason for Visit via Type: Derreatabagic Problem There Complaint: Make Congenital New on back History of Present Illness the patient appear it! No then 6d this episode start? Mis then 6d this episode start? Mis there 6d it start? back fow long have you had this the distribution? Scattered That is the clien? waried light-dark brown with it the color? waried light-dark brown with it is consistency? four does a first to poo? The is the consistency? four does a first to poo? Other: Previous lix statuent. Does Lermatological history poose CP's most likely treatment derreatabologis? Would you have normally sent is princed to a dermatologis? Medical History are History gestric taker Ended to go to bee | Fresh Thre 02 55 34 PM Fresh Type: Dermantsbegis Prablem Chief Conplaint: Mult Congenital New on back PHIStory of Present Illness Does patient appear all No When did this episode start? How long have you had this problem? When det skin problem fiel to patient? What is the clost? What is the clost? What is the clost? What is the consistency? Congenital one, R/O Atyp/dysplastic dermatological history PCP's most blocky treatment plan Would you have normally sent this patient to a dermatologist? Audio: PMedical History Part Hartory: Institute Room Aderger: Secal Blattory. | railes r | No. Control of the Co |
| Reason for Visit ist Type: Decreased begin Problem That Complete: Mult Congenial New on back History of Present Illness Does patient appear it! No Then 6d this episode start? Mis Then 6d this episode start? In the color of the circle start? In the color of the circle start? In the circle start in the circle | PREASON FOR VIsit Visit Type: Dermatnibegic Problem Charl Conglainer Mult Congenital New on back PHIstory of Present Illness Does patient appear di No When ded the proof of start? In How long have you had this arobhem? Dark How does shin problem feel to putual? What is the distribution? Stattered What is the color? Varied light-dark brown What is the color? What is the constancy? How does a feel to you? What is the constancy? How does a feel to you? Coher. Previous the stattery PCP's most likely treatment PCP's most likely treatment PCP's most likely treatment Plant Would you have acrossly sent this princet to a dermatologist? Audio: PMedical History Part History gastric taker Medicalous (Galade does of Coher dermatologist) Secant Entrory gastric taker Secant Entrory. Secant Entrory. Secant Entrory. Secant Entrory. Secant Entrory. Secant Entrory. | /as Dan 06/34/98 | Canditino ID: 980624145744CH |
| Reason for Visit int Type: Demonstrategic Problem Near Compleion: Make Congenital New on back History of Present Mness best pairces appear all No then del this epusode start? Make took long have you had his best booken? There del is start? back tow does skin problem feel to start? That is the distribution? Scattered That is the clord? waied light-dark brown No researc? That is the consistency? The start between the consistency? The start between the consistency? The start between the consistency? The consistency is the consistency. The consistency is the consistency? The consistency is the consistency? The consistency is the consistency. The consistency is the consistency is the consistency is the consistency. The consistency is the cons | PREASON FOR VISIT Visit Type: Dermanulogic Problem Chief Conglaint Mult Congenital New on back PHIStory of Present Illness Does patient appear all No When did this reprode start? Idea How long have you had this should be shown be start and the shown does taken problem feel to patient appear all the colors. When it the colors. Stattered What is the colors. Wand fight-dark brown No Other ASX What is the colors. No Other ASX What is the colors. No Other and thench under severally What is the consistency? How does a feel to you? Other. Previous he statens. Does Dermand-logical history. Does PCP's comments. Does PCP's most kiety desposis. PCP's most kiety desposis. PCP's most kiety the ament plant Would you have a cornally seest this patient to a dermanologist! Audio: *Medical History Past History: gastric taker Medical Cock der eight. Second Aberger: Second Estatory. | | |
| Set Type: Decrease abegin Problem Need Complaint: Medic Congenital New on back History of Present Illness Despations appear di No These del dis pool of start? Low long barre you had this obtained from the distribution of the colors. Debrare del di start? Low of does shan problem feel to got of start to get of the distribution of the distri | Visit Type: Dermantabegis Problems Charl Complainer Multi Congenital New on back PHIstory of Present Illness Does patient appear all New on back When did the spirode start? Me How long have you had this arobhem? Where did it start? back How does skin problem firel to patient? What is the cloted? varied light-dark brown Did the rath Unrich under varied light-dark brown What is the consistency? How does it first to poo? Other. Dermandological history Dermandological history DeP's comments PCP's most bledy treatment place Would you have acrountly sent this patient to a dermatologist? Audio: PMedical History Part Hartory gastric taker Medical bettory. Secant Bestory. | Erdical Code . | · |
| Set Type: Decrease abegin Problem Need Complaint: Medic Congenital New on back History of Present Illness Despations appear di No These del dis pool of start? Low long barre you had this obtained from the distribution of the colors. Debrare del di start? Low of does shan problem feel to got of start to get of the distribution of the distri | Visit Type: Dermantabegis Problems Charl Complainer Multi Congenital New on back PHIstory of Present Illness Does patient appear all New on back When did the spirode start? Me How long have you had this arobhem? Where did it start? back How does skin problem firel to patient? What is the cloted? varied light-dark brown Did the rath Unrich under varied light-dark brown What is the consistency? How does it first to poo? Other. Dermandological history Dermandological history DeP's comments PCP's most bledy treatment place Would you have acrountly sent this patient to a dermatologist? Audio: PMedical History Part Hartory gastric taker Medical bettory. Secant Bestory. | Reason for V | lsit |
| History of Present Illness Despated appear it? No Phene del this episode start? Me from the first problem feel to from does skin problem feel to from del to skin problem feel to from del to skin problem feel to from del to skin problem feel to from does skin problem feel to from does skin problem feel to from does skin problem feel from feel to skin problem feel from feel | Chief Conylinate Dick Congenital New on back PHIstory of Present Illness Does patient appear #1 No When feel this rejected start? In How long have you had this problem? Where dod is start? How does shin problem feel to patiental? What is the color? What is the color? What is the color? What is the color? What is the consistency? How does is first to you? Other: Previous trictanent. Dermatological history Der's comments PCP's most likely desposis. PCP's most likely desposis. PCP's most likely desposis. PCP's most likely treatment that patient to a dermatologist? Audio: PMedical History Past History gastric taker Medicalous (gashed of CCP Medical History Past History gastric taker Secal History. Secal History. Secal History. Secal History. Secal History. | | |
| then did this epus od start? Afticover long have you had this colories? Afticover long have you had this colories? Afticover long skeep problem fact to start? Afticover long skeep skeep problem fact to start start and start start to clor? Afticover long skeep sk | Does patient appear al No African Africa | | |
| then did this epus od start? Afticover long have you had this colories? Afticover long have you had this colories? Afticover long skeep problem fact to start? Afticover long skeep skeep problem fact to start start and start start to clor? Afticover long skeep sk | Does patient appear al No African Africa | | |
| then did this epus od start? Afticover long have you had this colories? Afticover long have you had this colories? Afticover long skeep problem fact to start? Afticover long skeep skeep problem fact to start start and start start to clor? Afticover long skeep sk | Does patient appear al No African Africa | | |
| then did this epus od start? Afticover long have you had this colories? Afticover long have you had this colories? Afticover long skeep problem fact to start? Afticover long skeep skeep problem fact to start start and start start to clor? Afticover long skeep sk | Does patient appear al No African Africa | History of Pr | esent Miness |
| Then field this episode start? Intered del is start? There ded is start? There ded is start? There is the chiral-start That is the chiral-start That is the color? That is the consistency? The color is first to poor Other: Territoral Prestations Territoral Device Compensation Territoral Device Compensa | When did this spicode start? How long have you had this problem feel to paired? What is the distribution? What is the clost? What is the constancy? Other. Previous tresturest poone Demandological bistory PCP's comments PCP's must keep deapoist. Congressal one, R/O Atyp/dysplastic dermatologic val. plan. Would you have normally sent this pairest to a dermatologist? Audio. PMedical History Past Hartory: Medictalogic residency. CCP Medictal History Past Hartory: Medictalogic residency CCP Medictal History Sense Medictaly. CCP Medictal History Sense Medictalogic. CCP Medictal History. | | |
| There ded it start? back | Merce ded it start? Now deer skin problem feel to pairsia? What is the color? What is the color? What is the color? What is the colorsacco;? What is the consistency? Coher: Previous trictment. Dermatological listory Dermatological listory DerP's comments PCP's most likely deagnosis. PCP's most likely treatment class Would you have acrossly sens this princit to a dermatologist? Audio: PMedical History Past History gastric taker Medicalous (schole drug desc, duraino) Rocowo Alergier: Social Eletary. | | art? Mrs |
| There ded it start? back | Merce ded it start? Now deer skin problem feel to pairsia? What is the color? What is the color? What is the color? What is the colorsacco;? What is the consistency? Coher: Previous trictment. Dermatological listory Dermatological listory DerP's comments PCP's most likely deagnosis. PCP's most likely treatment class Would you have acrossly sens this princit to a dermatologist? Audio: PMedical History Past History gastric taker Medicalous (schole drug desc, duraino) Rocowo Alergier: Social Eletary. | Hour long have you had | |
| tow does skin problem feel to stitusal? Char is the darehusion? Char is the darehusion? Scattered Public is the close? What is the consistency? That is the consistency? That is the consistency? That is the consistency? Cour does a feel to poo? Other: Permissi orgic al history CP's comments CP's comments CP's mont likely treatment Lan: CP's mont likely treatment Lan: Yes Todd you have normally send as pained to a derinatologis? Weddical History an History gastric uker Ledensoon (see bde OCP | Coher ASX What is the durabusion? What is the close? What is the close? What is the consistency? Coher. Coher. Corean close a first to poo? Coher. Corean close a listory CPP's comments PCP's comments PCP's most likely treatment plan. Congressial one, R/O Atyp/dysplastic dermatologis? Audio: PMedical History Past Hartory: Medical History Past Hartory: Medical Coher durabool (achode doug dote, duraboot (achode doug dote, duraboot) Koowo Alerger: Social Electory. | problem? | |
| That is the distribution? That is the distribution? That is the color? That is the color? That is the color? That is the color? That is the consistency? The consistency? Tow does a first to poo? Other: Provide the consistency? Other: Provide the statement CP's comments CP's comments CP's most kirch diagnosis CP's most kirch diagnosis CP's most kirch diagnosis To's most kirch dia | What is the distribution of Seatered What is the color? Seatered What is the color? Which is the consistency? What is the consistency? How does a first to pool? Other. Deriving the statest pool Other. Deriving the statest pool Person of the statest pool Person of the statest pool Person the statest pool Person the statest pool Person the statest pool Audio: PMedical History Part Hartory gastric taker Medication (Galvide dougles) Known Alerger: Secal Hartory. | | |
| That is the distribution? That is the color? This is the color? This is the consistency? This is the consistency? This is the consistency? The The consi | What is the classificant What is the color? What is the color? What is the consistency? Coher: Previous by attences Dornat closign al history DOP's comments PCP's most likely desposis. PCP's most likely treatment plan. Would you have normally sent this painest to a derunatologist? Audio: PMedical History Part History: Medication (actived adores) Known Alerger: Social Metarry. | | Other ASX |
| Phase is the color? varied light-dark brown All the rath blanch under research? Phase is the consistency? From the consistency? Other: Promost lix statence. Permutological history CP's comments CP's comments CP's most lix by dagnosis. CP's most lix by dagnosis. CP's most lix by the atment derected on the byte de | What is the color?. Varied light-dark brown No | | |
| No Plant is the consistency? Plant is the consistency? From the consistency? From the consistency? From the consistency. CP's comments. CP's most likely deagnosis. CP's most likely treatment dermatologic val. Interval of the consistency of the consistency. CP's most likely treatment dermatologic val. Interval on the consistency of the consistency | Did the resh blanch under versus? What is the consistency? How does it first to you? Other. Previous trestoscok. Doose Dorous elogical bistory PCP's comments PCP's most likely desposes. Congressal one, R/O Atyp/dysplastic dermatologic val. plan. Would you have normally sent this painest to a dermatologis? Audio: PMedical History Past Hartory: Jantine taker Medications (achide dougless) Koown Akerger: Secal Bartory. | What is the color?. | |
| // That is the consistency? // That is the consistency? // That is the consistency? // Cow does a first to poo? Other: // Does // Comments // CP's comments // CP's comments // CP's most likely deagnosis // CP's most likely treatment // CP's most | What is the consistency? How does is first to poo? Other. | | |
| Composition of the state of the | Coher. Previous trasserst. Dermatological Entory. PCP's comments PCP's most kicely deagnosis. Congenical card, R/O Atyp/dymbastic dermatologic real. Yes Would you have normally sent this painest to a dermatologist? PMedical History Part Entory: Indeduction (net/det doug dosts, dureiso): Known Alerger: Secial Entory. | pressure? | |
| Other: provided the statement poons CP's commented: CP's most likely deagnosis. CP's most likely treatment dermatologist read. Interval you have normally send as painest to a destructionary. Medical History an Hartory: gentlie taker GCP gentlie taker GCP GCP Gedestions (see hode GCP | Other Previous trestores poon Dermatological Estory poon PCP's comments PCP's most likely desposis. Congressal one, R/O Atyp/dysplastic dermatologic real plan. Would you have normally sent this painest to a dermatologist? Audio: PMedical History Past Hartory pastric taker Medicalous (actude dougles) Koowo Akerger: Social Estory. | What is the consistency? | |
| remost it states pool formatological history pool CP's contracts CP's contracts CP's most likely deagnosis CP's most likely it estiment late: Yould you have normally sent its painest to a dermatologist? Medical History are History are History federations (see hode OCP | Previous trestorest poone Dereustological bistory poone PCP's countriest PCP's most likely diagnosis. PCP's most likely diagnosis. Congressal cevi, R/O Atyp/dysplanic PCP's most likely trestment dermatologic eval dermatologic eval Yes this painest to a dermatologist? Audio. PMedical History past History gastric uker OCCP drong dore, duriesio): Known Akerjer: Social History. | How does it fired to you? | |
| cerematological history pone CP's comments CP's most kicely deagnosis. Congenital nevi, R/O Atyp/dymplastic CP's most kicely treatment dermatologic real less and you have normally sent as a princet to a dermatologis? Wedical History an History games offer derivation (see hole OCP | Dermatological history poore PCP's comments PCP's most likely diagnosis. Congressal nevi, R/O Atyp/dysplastic dermatologic eval. dermatologic eval. Would you have normally sent this painest to a dermatologist? Audio. PMedical History Past History: Mediction (nchole douglestes): Known Alerger: Social History. | Previous treatment | |
| CP's comments CP's most kicely deagnosis CP's most kicely treatment dermatologic real less prient to a dermatologis? Wedical History an History gentric older GCP GCP | PCP's comments PCP's most likely diagnosis. Congesial nevi, R/O Atyp/dymiastic dermatologic eval. Would you have normally sent this painest to a dermatologist? Audio: Medical History Part History: Medication (nchde dougles): Known Alerger: Social History. | | |
| CP's most kicely treatment decreaselogic twal last: Vest in painted to a decreaselogical last in painted control last in last | PCP's most kicky treatment lean Would you have acrossly seed fris periods to a decreasiologist? Audio: PMedical History Past History: gestric taker Medicalson (activity Andro, dorse, duraino): Known Alexgier: Social Elettory. | PCP's comments | |
| Acc. Fould you have normally sent as pained to a derivatologist? Medical History are Hartory: generic taker food asson (see hade | Would you have normally sent this painest to a dermatologist? Audio: Medical History Part Hartory: Medications (active): CCP drawdon, dore, drawino): Known Alergies: Social Hartory. | PCP's most likely diagno | sis Congenital ceré, R/O Atyp/dysplastic |
| Void you have normally sent if patient to a derivatiologist? Medical History are History: Interpretation Interpretatio | Would you have acrossly sent this pained to a derivatelegat? **Medical History** Part History** Audion Audion Audion | | ent dermatologic eval. |
| is pained to a dermatologist? Medical History an History gastric older dedications (see bode OCP | PMedical History Pur Hartory garante taker Medicalon (Gubde dougles of the dougl | | Yes |
| Medical History an Entroy: generic vicer Gedenson (no bde OCP | Audo: PMedical History Part History: gastric taker Medications (actable OCP drug dore, davision): Known Alergier: Social History: | | |
| Medical History aut Hartory: dedications (sachide OCP | Medical History Past Bartory: | Audo: | |
| art Hartory: gautric teleer de decisions (sachde OCP | Part History: gastric taker Medicisions (achade drug, dore, dureino): Known Alexger: Social History. | | |
| dedications (actuale OCP | Medications (achide OCP drug, dore, dureiso): Kaowa Alergier: Social Huntery. | | |
| | drug, dose, dureisa); Kaowa Allergier: Sozial Hunary. | | 7 |
| | Known Altergier: Social Hartory: | Medications (actuals | OCTP |
| | Social Hunory. | | |
| | | AND THE PARTY SET S. | |
| | | Social Hutory | , |
| | | PCP's most blocky deagon PCP's most blocky treatm place Would you have normall this painest to a destructed Audio: Medical Hist Past Hatory: | orra dermatologic eval. ly seak Yes logist? OFY gastric teker |
| | | CDOMO MOCIBERS. | |
| | | F117 | , · |

FIG. 3. Request for consultation.

and resolution were not specifically addressed by the technicians but were subject to critique by the evaluating specialists.

Only patient record numbers identified the images. Connectivity between sites was achieved using Transmission Control Proto-

col/Internet Protocol (TCP/IP) over a wide area-data network with a minimum of 1.5 mbps between sites. Participating dermatologists were free to view cases over the Internet from their home, and they did so using either a DirectTVTM satellite link or a cable modem. Up-

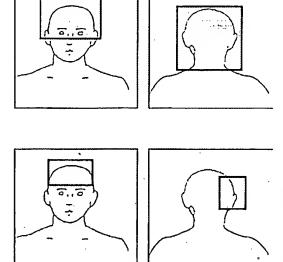


FIG. 4. Image protocol example: scalp (top/back/sides). General considerations: The patient should be seated. The head should be inclined forward or rotated so that the area to be imaged lies on a plane with the camera back. The patient may assist by helping to part the hair to better expose scalp, or the hair may be taped or otherwise secured away from the affected area. The patient should remove jewelry and be draped to avoid visual distractions of clothing. Image 1: Image the general scalp area affected (1:8 ratio). Images 2-4: Image closeups of the affected area (1:4, 1:2, and 1:1 ratio). Additional special images: A fifth photograph (1:4 or 1:2) should be made at an oblique 45° angle.

loading of images from the digital camera to the PC took ~20 s per image, and transmission to the server took ≤40 s. Images were saved as medium-resolution JPEG files occupying ~700 kb of space for each. An automatic electronic message to one of the two dermatologists (Da or Db) alerted him or her that a case was ready for review. Cases were randomly assigned to one of the dermatologists by the imaging technician.

Imaging technicians at both sites maintained a log of a patient's identification number, study number, and dates of all surveys done. In addition, the technician maintained a daily occurrence log for any problems that arose throughout the process from consent to receipt of consult by the PCP. These occurrences were phoned to the study coordinator at Partners Telemedicine for immediate resolution.

Specialist review. Upon electronic notification of a pending consultation, the two board-certi-

fied dermatologists reviewed the patient history and images and rendered an opinion using a 2-business-day turnaround time in routine cases or a 1-business-day turnaround time upon PCP's request (Fig. 5). In this study, no PCP requested the 1-day turnaround. Following completion of the review, an e-mail message, sent automatically following specialist completion of the consultation, alerted the PCP that the consultation was ready for viewing on the server.

Specialist responses to PCPs were grouped into-three categories: (1)-a-diagnosis and treatment plan; (2) a request for additional information or images, and (3) an inability to determine the condition from the images provided and a recommendation that the patient be seen by a "live" dermatologist. Additionally, if . the PCP thought that further examination and treatment were needed, the patient was informed that an appointment would be made for him or her with a local dermatologist. Partners Telemedicine study personnel followed up on all such cases to ensure that an appointment was made. Routine follow-up calls were made on a technical evaluation patients to assess their progress and opinion regarding their care.

Evaluation tools. Patients were queried as to satisfaction with the overall physician visit, adequacy of explanations, answers to questions. and concerns about the photographic study, courtesy and respect of office personnel including the imaging technician, comfort with this new method of care, and satisfaction with time spent taking pictures. Patients ranked their satisfaction from 5 (strongly agree) to 1 (strongly disagree). PCPs were polled as to their comfort with the equipment and procedures for remote consultation, convenience of teleconsultation, timelineness of teleconsultations, quality of the teleconsultants' diagnosis and recommended treatment, likelihood of continued use of teleconsultations, and comfort with the security of teleconsultations.

RESULTS

Twelve PCPs referred patients, and no patient refused to participate in the study.



| 1- Lab Order (24-Jun 1- Request for Consul- Consultation As | hation (24-Jun-98) | 0(E)5/00 00 54 07 PM | |
|--|--|------------------------------------|-------------------------------------|
| -Language this ar dysplanic next Present document the "about" commencements for any | end to when them mouthly w callinging of containly (10 stations) 9 | noma, these could be followed. The | ie prilim ceeds to rashe should: |
| Quality of Image (Securitari) | 5 | | |
| Comments on Image Quality | | | |
| Minutes Spect on : Assessment | 8 | | |
| Audio: | | | |
| | | | : |
| Hours | | PARTNERS | 7 S |

FIG. 5. Specialist response.

The evaluation phase lasted 16 working days. A total of 18 patients were seen. The breakdown of those figures between the two sites was as follows: MGH saw 11 patients, and Cape Ann saw 7 patients. Fifteen female and 3 male patients were enrolled.

Physicians and patients responded to ques: <tionnaires-concerning their reaction to the pro-</p> gram. The experience was generally positive for participants. Asked to report their satisfaction with this new method for conducting dermatologic examination, almost all patients thought that their concerns were addressed, they were comfortable with this new method of care, and the overall experience was satisfactory (Tables 1 and 2). Satisfaction concerning care between the study patients who were imaged and control patients who were not was not qualitatively different. Physician responses (Table 3) were more reserved. The overwhelming majority wished to continue teleconsultations when the service be-"strongly agree," 23.1% "agree").

The dermatologists graded the quality of images on a scale of 1 to 5, certainty of diagnosis on a scale of 1 to 10, and the time spent assessing the case. Image-quality assessment ranged from 5 (n = 5) to 2 (n = 2), with a mean of 3.8. Mean certainty of diagnosis was 7.4 with a range of 2 (n = 1) to 9 (n = 7). Time spent on each case by the dermatologist ranged from 3 min (n = 1) to 10 min (n = 7), with a mean time to completion of 6.8 min. In 82% of cases, the dermatologist was confident in making a diagnosis and treatment recommendation. In 18% of cases, the dermatologist requested additional information or images. In no case did the specialist believe that a face-to-face encounter was required because of an inability to read the images. Finally, the number of images stored for each case was tracked. The mean number of images uploaded was 6.1, ranging from 3 (n = 2) to 9 (n = 4). In most instances, higher numbers of comes available on a regular basis (76.9% images correlated with imaging of multiple sites on a patient.

TABLE 1. STUDY PATIENTS' QUESTIONNAIRE

| Question | Overall Score | MGH ··· Score | Cape Ann Score |
|---|------------------|------------------|-------------------|
| Overall I was satisfied with my visit to my physician today as compared to similar visits to this doctor. | 4.56 | 4.55 | 4.57 |
| I was satisfied that my questions and/or concerns about this new photographing study were addressed and answered. | 4.56 | 4.55 | 4.71 |
| I was given respect and courtesy by all office personnel, including the person who took the pictures. | 4.78 | 4.73 | 4.86 |
| I was comfortable with this new process of care. | 4.56 | 4.36 | 4.86 |
| I was satisfied with the amount of time that was spent in taking the pictures. | 4.22 | 4.55 | 3.86 |

DISCUSSION

The system centralizes data in one-location and allows retrieval of information from the centralized storage area. This permits efficient storage and retrieval of information, including appropriate history and images, as well as measuring outcomes.

The presentation software for this project is the ubiquitous Web browser. Generally, Microsoft's Internet Explorer and Netscape's Navigator programs are bundled as standard software on a personal computer. The system employed here allows the vast majority of PCs available off-the-shelf to be used as work stations. This dramatically lowers the cost of image interpretation while providing an environment in which a practitioner can interpret images and work at any work station within a network or at home.

Technology requirements for image acquisition are minimal. Again, an off-the-shelf personal computer is appropriate. The digital cap-

ture device can vary depending on the needs of the system. In this case, we chose a high-resolution photographic device as a benchmark because of the need to acquire high-resolution close-up images and to adhere to an imaging protocol. The digital capture device was the single most expensive component, but the price is going down. Currently we are investigating image capture devices for <\$1000.

The use of the Internet as a telecommunication vehicle has both positive and negative implications. One positive implication is reduced cost. The structure of the Internet is such that the cost of being on the network is low in most places in the world (requiring a local phone call and a monthly subscription fee for an Internet service provider). Another advantage is the ubiquity of client and server software for Web applications. Potential negatives of using the Internet have to do with bandwidth, security, and quality of service. In this study bandwidth was not particularly significant, as image sizes

TABLE 2. CONTROL PATIENTS' QUESTIONNAIRE

| Question | Overall Score | MGH Score | Cape Ann Score |
|--|------------------|--------------|-------------------|
| Overall I was satisfied with my visit to my physician today. | 4.3 | 4.76 | 3.43 |
| I was satisfied that my questions and/or concerns about this new study were addressed and answered. | 4.45 | 4.54 | 4.29 |
| I was satisfied that I was given respect and courtesy by office personnel, both medical and support staff. | 4.55 | 4.85 | 4.00 |
| I was comfortable with the existing way care is given by my physician. | 4.55 | 4.77 | 4.14 |

W.

TABLE 3. PRIMARY CARE PHYSICIAN SATISFACTION
WITH TELEDERMATOLOGY

| Question | Overall Score |
|--|------------------|
| I am comfortable with the use of the equipment and procedures for obtaining a remote consult. | 4.5 |
| Teleconsult was more convenient than a traditional consult | 3.5 |
| Teleconsults were less timely than traditional consults. | 2.6 |
| I am satisfied with the quality of the teleconsultants' diagnosis and recommended treatment. | 4.1 |
| I am more likely to use teleconsults (given the same group of patients) because they provide more diagnostic certainty. | 3.5 |
| I am more likely to use teleconsults (given the same group of patients) because they are convenient. | 4.6 |
| I am comfortable with the security of medical information transmitted in teleconsults as compared to the privacy and security of medical information | 4.3 |
| provided in traditional consults. I would like to continue using teleconsults when this study is over. | 4.8 |

were relatively small, and the transactions took place during low network traffic hours. Although we have been able to transmit, retrieve, and review images over a 56-kbps modern connection, the system is optimized with a minimum of 128 kbps transmission speed.

The main concern with Internet use in this application is security of information. This system applies several layers of security, but the security of any record in any health care system is at risk at any time. This program utilized the most sophisticated encryption available as a standard procedure.

The project demonstrated that the quality of service of the Internet and associated hardware-software applications are generally sufficient for a consultative practice. It should be pointed out that no decisions made during this trial were immediate or life-or-death decisions. Rather, the explicit commitment to our PCPs was a 2-business-day evaluation. This allowed for minimal technologic service disruptions to occur without affecting level of service. The endorsement of the Internet for this activity does not imply endorsement of the Internet for activities that involve more time-critical and mission-critical applications.

Another noteworthy feature of this application is our use of an imaging technician and an imaging protocol for image acquisition. We considered several models in devising the system, including the ability or desirability of PCPs acquiring their own images, the use of highly skilled allied health care professionals to acquire images, and the use of technicians. We chose to use technicians for several reasons. From an economic prospective, it is desirable to create systems in which the cost of labor for implementation is lower. Another aspect of the application is efficiency for the PCP. Although some PCPs initially raised concerns about filling out relatively lengthy lustory forms, they quickly adapted to this element of the case flow. Subsequent to the evaluation phase, one PCP reported that filling out the form initially took ≤5 minutes; with regular utilization, that time has been reduced to 1-2 min. Further refinement of the Web-based history forms will reduce the actual typing by utilization of "pick lists."

In many practices, existing personnel of a practice could be trained to acquire and download the images as a part of their normal functioning. In the technical evaluation phase of this deployment, technicians worked full time on debugging the system, explaining trial information to patients, training PCPs, and completing patient questionaires. In the implementation phase, these technicians are cross-trained to perform a variety of routines within the clinical environment.

Patients approved the use of this technology, particularly at the remote site (Cape Ann Medical Center in Gloucester, Massachusetts, a distance of 58 miles from the tertiary care center). They valued the convenience and rapid treatment, and they believed that their PCP was giving them sound medical advice. Thus, the main change agents in the modification of the health care process are likely to be primary care doctors.

Another factor regarding this research is the restriction of this activity to urban and suburban areas. This is new ground for telemedicine applications to break. Most telemedicine applications have been utilized in one of four markets (underserved rural, military, incarcerated, and international). These markets share wide geographic disbursement of patients and doctors or difficulty in patient or physician transport as the major issues for which telemedicine has been

viewed as a solution. In this case, the investigation centered on the use of telemedicine as an efficiency tool in an urban environment where access to care is generally not a problem.

Further research in this area will include an assessment of whether this approach to care efficiency in an urban area has merit. Measurements will include quality of outcomes and cost of service.

ACKNOWLEDGMENTS

This work was supported by Partners Health-Care System, Inc. The authors thank Marc Cail for his contribution as an imaging technician; Wendy Calderon and Yaysie Figueroa for their contributions as imaging technicians, critical reviewers of the imaging protocol, and conduct of the follow-up survey; and Diane Jordan for an important contribution to the design and initiation of the project.

REFERENCES

- Kirsner RS, Federman DG. Lack of correlation between internists' ability in dermatology and their patterns of treating patients with skin disease. Arch Dermatol 1996;132:1043-1046.
- Ramsey DL, Fox AB. The ability of primary care physicians to recognize common dermatoses. Arch Dermatol. 1981;117:620-622.
- Kvedar JC, Edwards RA, Menn ER, et al. The substitution of digital images for dermatologic physical examination. Arch Dermatol 1997;133:161--167.
- Lowitt MH, Kessler II, Kaufman CL, et al. Teledermatology and in-person examinations. Arch Dermatol 1998;134:471–476.
- Perednia DA, Gaines JA, Rossum AC. Variability in physician assessment of lesions in cutaneous images and its implications for skin screening and computerassisted diagnosis. Arch Dennatol 1992;128:357–364.
- Whited JD, Homer RD, Hall RP, et al. The influence of history on interobserver agreement for diagnosing actinic keratoses and malignant skin lesions. J Am Acad Dermatol 1995;33:603-607.
- Drake LA. Impact of onychomicosis on quality of life. J Am Podiatr Med Assoc 1997;87:507-511.
- Finlay AY. Quality of life measurement in dermatology. Br J Dermatol 1997;136:305–314.
- Ginsburg IH. The psychosocial impact of skin disease. Dermatol Clin 1996;14:473–484.
- Clark RA, Rietschel RL. The cost of initiating appropriate therapy for skin diseases: A comparison of der-

- matologists and family physicians. J Am Acad Dermatol 1983;9:787-796.
- Pariser RJ, Pariser DM. Primary care physicians' errors in handling cutaneous disorders. J Am Acad Dermatol 1987;17:239–245.
- Bailit H, Federico J, McGivney W. Use of outcomes studies by a managed care organization: Valuing measured treatment effects. Med Care 1995;33:AS216– AS225.
- Denton TA, Diamond GA. For goodness' sake: Expected therapeutic benefits as a basis for healthcare delivery. Clin Chem 1995;41:799-804.
- Kirsner RS, Federman DG. Patient satisfaction: Quality of care from the patients' perspective. Ards Dermatol 1997;133:1427-1430.
- Gabriel SE. Primary care: Specialists or generalists. Mayo Clin Proc 1996;74:415–416.
- Brunner LK, McKnight MM. Are gatekeepers necessary? Best Pract Benchmarking Health: 1997;2:52-56.
- Hall RC. Ethical and legal implications of managed care. Gen Hosp Psychiatry 1997;19:200-208.
- Plumeri PA. Managed care and risk management. Gastroenterol Clin North Am 1997;24:895-910.
- 19. Rees AM. Communication in the physician-patient relationship. *Bull Med Lib Assoc* 1993;81:1–10.
- 20. What are the risk management issues surrounding telemedicine. Risk Management Foundation. http://www.rmf.org/b4269.html
- Shotwell LF. Taming liability of telemedicine transactions: Technology adoption poses catch-22 for providers. Arent Fox Kintner Plotkin & Kahn. http://www.arentfox.com/telemed/articles/tamingliab.html
- Allaert FA, Dusserre L. Legal requirements for teleassistance and tele-medicine. *Medinfo* 1995;8Pt2:1593– 1595.
- Filiberti D, Wallace J, Koteeswaran R, Neft D. A telemedicine transaction model. Telemed J 1995;1:237–247.
- Vidmar DA. Plea for standardization in teledermatology: A worm's eye view. Telemed J 1997;3:173–178.
- Balas EA, Jaffrey F, Kuperman GJ, et al. Electronic communication with patients: Evaluation of distance medicine technology. JAMA 1997;278:152–159.
- Cimino JJ, Socratous SA, Clayton PD. Internet as clinical information system: Application development using the world wide web. J Am Med Inform Assoc 1995;2:273–284.
- Afrin LB, Kuppuswamy V, Slater B, Stuart RK. Electronic clinical trial protocol distribution via the world wide web: A prototype for reducing costs and errors, improving accrual, and saving trees. J Am Med Inform Assoc 1997;4:25–35.
- Schosser R, Weiss C, Messmer K. A local area network for medical research; planning, realization and experience. Methods Inf Med 1991;30:53-64.

Address reprint requests to:
Joseph C. Kvedar, M.D.
Partners Telemedicine
1 Longfellow Place, Suite 216
Boston, MA 02114

This Page is Inserted by IFW Indexing and Scanning Operations and is not part of the Official Record

BEST AVAILABLE IMAGES

Defective images within this document are accurate representations of the original documents submitted by the applicant.

| Defects in the images include but are not limited to the items checked: |
|---|
| BLACK BORDERS |
| ☐ IMAGE CUT OFF AT TOP, BOTTOM OR SIDES |
| ☐ FADED TEXT OR DRAWING |
| BLURRED OR ILLEGIBLE TEXT OR DRAWING |
| ☐ SKEWED/SLANTED IMAGES |
| ☐ COLOR OR BLACK AND WHITE PHOTOGRAPHS |
| ☐ GRAY SCALE DOCUMENTS |
| ☐ LINES OR MARKS ON ORIGINAL DOCUMENT |
| ☐ REFERENCE(S) OR EXHIBIT(S) SUBMITTED ARE POOR QUALITY |
| OTHER. |

IMAGES ARE BEST AVAILABLE COPY.

As rescanning these documents will not correct the image problems checked, please do not report these problems to the IFW Image Problem Mailbox.